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SUSY–QCD Corrections to Higgs Boson Production at Hadron Colliders

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Abstract

We analyze the next-to-leading order SUSY-QCD corrections to the production of Higgs particles at hadron colliders in supersymmetric extensions of the Standard Model. Besides the standard QCD corrections due to gluon exchange and emission, genuine supersymmetric corrections due to the virtual exchange of squarks and gluinos are present. At both the Tevatron and the LHC, these corrections are found to be small in the Higgs-strahlung, Drell–Yan-like Higgs pair production and vector boson fusion processes.

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1. Introduction

A firm prediction of supersymmetric extensions of the Standard Model (SM) [1] is the existence of a light scalar Higgs boson. In the Minimal Supersymmetric Standard Model (MSSM) the Higgs sector contains a quintet of scalar particles [two CP-even h and H, a pseudoscalar A and two charged $H^\pm$ particles] [2], the Higgs boson h of which should be light, with a mass $M_h \lesssim 135$ GeV [3]. If this particle is not found at LEP2 [4], it will be produced at the upgraded Tevatron (where a large luminosity, $\int \mathcal{L} \sim 20$ fb^{-1}, is expected) [5] or at the LHC [6, 7], if the MSSM is indeed realized in Nature.

At hadron colliders, the dominant production mechanism for neutral Higgs particles is the (heavy quark) loop induced gluon fusion process, $gg \to \Phi$ with $\Phi = h, H$ or A [8]. Since the Higgs particles in the mass range of interest, $M_\Phi \lesssim 135$ GeV, dominantly decay into bottom quark pairs, this process is rather difficult to exploit at the Tevatron because of the huge QCD background [5]. In contrast, at the LHC rare decays of the lightest h boson to two photons or decays of the heavy H, A boson to τ and μ lepton pairs make this process very useful [6].

Additional Higgs production mechanisms at hadron colliders are provided by:

a) Higgs-strahlung off W or Z bosons for the CP-even Higgs particles [due to CP-invariance, the pseudoscalar A particle does not couple to the massive gauge bosons at tree level]: $q\bar{q} \to V^* \to \Phi V$ with $\Phi = h, H$ and $V = W, Z$ [9]. At the Tevatron, the process $q\bar{q}' \to hW$ [with the h boson decaying into $b\bar{b}$ pairs] develops a cross section of the order of a fraction of a picobarn for a SM-like h boson with a mass below ~ 135 GeV, making it the most relevant mechanism to study [5]. At the LHC, both the $b\bar{b}$ and $\gamma\gamma$ decay modes of the h boson may be exploited [6].

b) If the heavier $H, A, H^\pm$ bosons are not too massive, the pair production of two Higgs particles in the Drell–Yan type process, $q\bar{q} \to \Phi_1\Phi_2$ [10–12], might lead to a variety of final states $[hA, HA, H^\pm h, H^\pm H, H^\pm A, H^+H^-]$ with reasonable cross sections [in particular for $M_A \sim M_H \sim M_{H^\pm} \lesssim 250$ GeV and small values of tanβ, the ratio of the vacuum expectation values of the two Higgs doublets] especially at the LHC. Moreover, neutral and charged Higgs boson pairs will be produced in gluon fusion $gg \to \Phi_1\Phi_2$ [11–13].

c) The production of CP-even Higgs bosons via vector boson fusion, $qq \to qqV^*V^* \to qq\Phi$ [14]: In the case of a SM-like h boson, this process has a sizeable cross section at the LHC. While decays of the Higgs boson into heavy quark pairs are problematic to be detected in the jetty environment of the LHC, decays into τ lepton pairs make this process useful at the LHC [15].

In addition to these types of processes, neutral Higgs boson radiation off heavy bottom and top quarks $[q\bar{q}, gg \to b\bar{b}\Phi, t\bar{t}\Phi]$ might play an important role in SUSY theories [16]. In particular, because the couplings of the Higgs boson to b quarks can be strongly enhanced for large values of tanβ, Higgs boson production in association with $b\bar{b}$ pairs can give rise to large production rates.

It is well known that for processes involving strongly interacting particles, as is the case for the ones discussed above, the lowest order cross sections are affected by large uncertainties arising from higher order corrections. If the next-to-leading QCD corrections to these processes are included, the total cross sections can be defined properly and in a reliable way in most of the cases.

For the standard QCD corrections, the next-to-leading corrections are available for most of the Higgs boson production processes. The K-factors [defined as the ratios of the next-to-leading order cross sections to the lowest order ones] for Higgs boson production via the gluon fusion processes have been calculated a few years ago [17]; the [two-loop] QCD corrections have been found to be significant since they increase the cross sections by up to a factor of two. The K-factors for Higgs production in association with a gauge boson (a) and for Drell–Yan-like Higgs pair production (b), can be inferred from the Drell–Yan production of weak vector bosons and increase the cross section by approximately 30% [18]. The QCD corrections to $gg \to \Phi_1\Phi_2$ are only known in the limit of light Higgs bosons compared with the loop-quark mass; they enhance the cross sections by up to a factor of two [13]. For Higgs boson production in the weak boson fusion process (c), the QCD corrections can be derived in the structure function approach from deep-inelastic scattering; they turn out to be rather small, enhancing the cross section by about 10% [19]. Finally, the full QCD corrections to the associated Higgs production with heavy quarks are not yet available; they are only known in the limit of light Higgs particles compared with the heavy quark mass [20] which is only applicable to $t\bar{t}h$ production; in this limit the QCD corrections increase the cross section by about 20–60%.

Besides these standard QCD corrections, additional SUSY-QCD corrections must be taken into account in SUSY theories; the SUSY partners of quarks and gluons, the squarks and gluinos, can be exchanged in the loops and contribute to the next-to-leading order total cross sections. In the case of the gluon fusion process, the QCD corrections to the squark loop contributions have been calculated in the limit of light Higgs bosons and heavy gluinos; the K-factors were found to be of about the same size as the ones for the quark loops [21]. The SUSY–QCD corrections to the other production processes are not yet available.

In this paper, we calculate the SUSY–QCD corrections to the Higgs production cross sections for Higgs-strahlung, Drell–Yan-like Higgs pair production and weak boson fusion processes. These corrections originate from $q\bar{q}V$ one-loop vertex corrections, where squarks of the first two generations and gluinos are exchanged, and the corresponding quark self-energy counterterms, Fig. 1. These corrections turn out to be small for reasonably large values of the squark and gluino masses, altering the cross section by a few percent only. For heavier masses, squarks and gluinos decouple and the SUSY-QCD corrections become tiny.

Note that genuine SUSY–QCD corrections are also present in the decays of the Higgs bosons into heavy quark pairs [22]. They are much larger than for the production in the

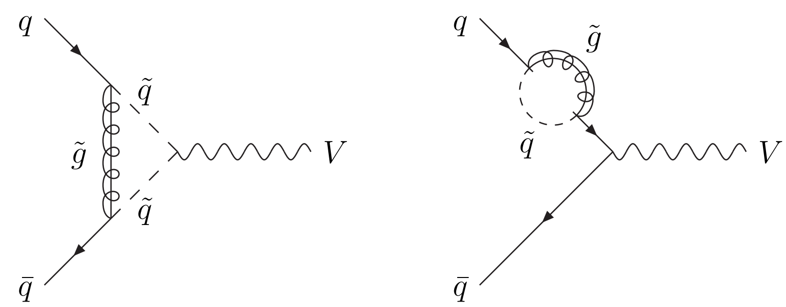

Figure 1: *Generic diagrams contributing to the SUSY-QCD corrections to the $q\bar{q}V$ vertex [$V = \gamma, Z, W$] at NLO.*

case of large mixing in the sbottom sector, being of the order of a few ten per cent, and decouple only slowly for large squark and gluino masses. They are being included in the program HDECAY [23] which calculates the decay widths and branching ratios of the MSSM Higgs particles.

2. QCD corrections to the production processes

2.1 Higgs-strahlung and Drell–Yan-like pair production processes

At hadron colliders, the lowest order partonic cross section for the Higgs-strahlung processes, $q\bar{q} \to V\Phi$ with $V = W, Z$ and $\Phi = h, H$, is given by [7, 9]

$$\hat{\sigma}_{\rm LO}(q\bar{q} \to V\Phi) = \frac{G_F^2 M_V^4}{288\pi\hat{s}} g_{\Phi VV}^2 (v_q^2 + a_q^2) \lambda^{1/2}(M_V^2, M_\Phi^2; \hat{s}) \frac{\lambda(M_V^2, M_\Phi^2; \hat{s}) + 12 M_V^2/\hat{s}}{(1 - M_V^2/\hat{s})^2} \qquad (1)$$

with the couplings $g_{\Phi VV} = \sin(\beta - \alpha)$ or $\cos(\beta - \alpha)$ for h and H respectively; $\hat{s}$ is the partonic c.m. energy and λ the usual two-body phase space function $\lambda(x, y; z) = (1 - x/z - y/z)^2 - 4xy/z^2$. v_q, a_q are the vector and axial-vector couplings of the quark q to vector bosons and are given by $v_q = 2I_q^3 - 4e_q s_W^2, a_q = 2I_q^3$ for $V = Z$ [e_q is the electric charge, I_q^3 the weak isospin of the quark and $s_W^2 = 1 - c_W^2 \equiv \sin^2\theta_W$] and $v_q = a_q = \sqrt{2}$ for $V = W$.

The partonic cross section for Drell–Yan-like Higgs pair production $q\bar{q} \to \Phi_1\Phi_2$, where at least one of the Higgs bosons is neutral, is given by [10, 11]:

$$\hat{\sigma}_{\rm LO}(q\bar{q} \to \Phi_1\Phi_2) = \frac{G_F^2 M_V^4}{288\pi\hat{s}} g_{\Phi_1\Phi_2 V}^2 (v_q^2 + a_q^2) \frac{\lambda^{3/2}(M_{\Phi_1}^2, M_{\Phi_2}^2; \hat{s})}{(1 - M_V^2/\hat{s})^2} \qquad (2)$$

where the couplings are given by: $g_{ZhA} = g_{WhH^+} = \cos(\beta - \alpha)$, $g_{ZHA} = g_{WHH^+} = \sin(\beta - \alpha)$ and $g_{WH^+A} = 1$. For charged Higgs boson pair production there is an s-channel photon exchange in addition to the Z-channel diagram, and the cross section is

given by [10, 12]:

$$\hat{\sigma}_{\rm LO}(q\bar{q} \to H^+H^-) = \frac{\pi\alpha^2(\hat{s})}{9\hat{s}}\left[e_q^2 + \frac{2e_q v_q v_{H^+}}{16s_W^2 c_W^2(1-M_Z^2/\hat{s})} + \frac{(v_q^2+a_q^2)v_{H^+}^2}{64s_W^4c_W^4(1-M_Z^2/\hat{s})^2}\right] \tag{3}$$

with $v_{H^+} = -2 + 4s_W^2$.

The hadronic cross sections can be obtained from convoluting eqs. (1–3) with the corresponding (anti)quark densities of the protons

$$\sigma_{LO}(pp \to V\Phi, \Phi_1\Phi_2) = \int_{\tau_0}^1 d\tau \sum_q \frac{d\mathcal{L}^{q\bar{q}}}{d\tau}\hat{\sigma}_{LO}(\hat{s}=\tau s) \tag{4}$$

where $\tau_0 = (M_V + M_\Phi)^2/s$ for the Higgs-strahlung and $\tau_0 = (M_{\Phi_1} + M_{\Phi_2})^2/s$ for the pair production processes, with s being the total hadronic c.m. energy squared.

The standard QCD corrections, with virtual gluon exchange, gluon emission and quark emission, are identical to the corresponding corrections to the Drell–Yan process [18, 24]. They modify the lowest order cross section in the following way [7, 18]

$$\begin{aligned}
\sigma &= \sigma_{LO} + \Delta\sigma_{q\bar{q}} + \Delta\sigma_{qg} \\
\Delta\sigma_{q\bar{q}} &= \frac{\alpha_s(\mu)}{\pi}\int_{\tau_0}^1 d\tau \sum_q \frac{d\mathcal{L}^{q\bar{q}}}{d\tau}\int_{\tau_0/\tau}^1 dz\ \hat{\sigma}_{LO}(Q^2=\tau z s)\ \omega_{q\bar{q}}(z) \\
\Delta\sigma_{qg} &= \frac{\alpha_s(\mu)}{\pi}\int_{\tau_0}^1 d\tau \sum_{q,\bar{q}} \frac{d\mathcal{L}^{qg}}{d\tau}\int_{\tau_0/\tau}^1 dz\ \hat{\sigma}_{LO}(Q^2=\tau z s)\ \omega_{qg}(z)
\end{aligned} \tag{5}$$

with the coefficient functions [24]

$$\begin{aligned}
\omega_{q\bar{q}}(z) &= -P_{qq}(z)\log\frac{M^2}{\tau s} + \frac{4}{3}\left\{\left[\frac{\pi^2}{3}-4\right]\delta(1-z) + 2(1+z^2)\left(\frac{\log(1-z)}{1-z}\right)_+\right\} \\
\omega_{qg}(z) &= -\frac{1}{2}P_{qg}(z)\log\left(\frac{M^2}{(1-z)^2\tau s}\right) + \frac{1}{8}\left\{1+6z-7z^2\right\},
\end{aligned} \tag{6}$$

where M denotes the factorization scale, μ the renormalization scale and P_{qq}, P_{qg} the well-known Altarelli–Parisi splitting functions, which are given by [25]

$$\begin{aligned}
P_{qq}(z) &= \frac{4}{3}\left\{\frac{1+z^2}{(1-z)_+} + \frac{3}{2}\delta(1-z)\right\} \\
P_{qg}(z) &= \frac{1}{2}\left\{z^2 + (1-z)^2\right\}.
\end{aligned} \tag{7}$$

The index + denotes the usual distribution $F_+(z) = F(z) - \delta(1-z)\int_0^1 dz' F(z')$.

Including the vertex correction due to the squark-gluino exchange diagram and the corresponding self-energy counterterm, the lowest order partonic cross section in eq. (4) will be shifted by

$$\hat{\sigma}_{\rm LO} \to \hat{\sigma}_{\rm LO}\left[1 + \frac{2}{3}\frac{\alpha_s(\mu)}{\pi}\Re e C(\hat{s}, m_{\tilde{q}}, m_{\tilde{g}})\right] \tag{8}$$

For degenerate unmixed squarks [as is approximately the case for the first two generation squarks], the expression of the factor C is simply given by

$$C(s, m_{\tilde q}, m_{\tilde g}) = 2\int_0^1 x\mathrm{d}x \int_0^1 \mathrm{d}y \log\frac{m_{\tilde g}^2 + (m_{\tilde q}^2 - m_{\tilde g}^2)x}{-sx^2y(1-y) + (m_{\tilde q}^2 - m_{\tilde g}^2)x + m_{\tilde g}^2 - i\epsilon} \tag{9}$$

In terms of the Passarino–Veltman scalar functions A_0, B_0 and C_0 [26] the expression of the function C reads

$$\begin{aligned} C(\hat s, m_{\tilde q}, m_{\tilde g}) &= 2m_{\tilde g}^2 C_0(\hat s, 0, m_{\tilde q}, m_{\tilde q}, m_{\tilde g}) - \frac{2}{\hat s}(m_{\tilde q}^2 - m_{\tilde g}^2)C_+(\hat s, 0, m_{\tilde q}, m_{\tilde q}, m_{\tilde g}) \\ &\quad +1 + B_0(\hat s, m_{\tilde q}, m_{\tilde q}) - 2B_1(0, m_{\tilde g}, m_{\tilde q}) \end{aligned} \tag{10}$$

with

$$\begin{aligned} C_+(s, 0, m_1, m_1, m_2) &= B_0(s, m_1, m_1) - B_0(0, m_1, m_2) + (m_2^2 - m_1^2)C_0(s, 0, m_1, m_1, m_2) \\ B_1(0, m_1, m_2) &= \frac{1}{2}\left[B_0(0, m_1, m_2) + (m_1^2 - m_2^2)B_0'(0, m_1, m_2)\right] \end{aligned} \tag{11}$$

where

$$B_0'(s, m_1, m_2) = \frac{\partial}{\partial s} B_0(s, m_1, m_2) \tag{12}$$

It should be noted that these results agree with the corresponding SUSY-QCD corrections to slepton pair production at hadron colliders [27].

2.2 The vector boson fusion processes

The differential leading order partonic cross section for the vector boson fusion process, $qq \to qqV^*V^* \to qq\Phi$ with $V = W, Z$ and $\Phi = h, H$ [with the couplings $g_{\Phi VV}$ given before] can be cast into the form [7, 14]

$$\begin{aligned} d\sigma_{LO} &= \frac{1}{4}\frac{\sqrt{2}G_F^3 M_V^8 q_1^2 q_2^2 g_{\Phi VV}^2}{[q_1^2 - M_V^2]^2[q_2^2 - M_V^2]^2}\Bigg\{F_1(x_1, M^2)F_1(x_2, M^2)\left[2 + \frac{(q_1q_2)^2}{q_1^2q_2^2}\right] \\ &\quad + \frac{F_1(x_1, M^2)F_2(x_2, M^2)}{P_2q_2}\left[\frac{(P_2q_2)^2}{q_2^2} - M_P^2 + \frac{1}{q_1^2}\left(P_2q_1 - \frac{P_2q_2}{q_2^2}q_1q_2\right)^2\right] \\ &\quad + \frac{F_2(x_1, M^2)F_1(x_2, M^2)}{P_1q_1}\left[\frac{(P_1q_1)^2}{q_1^2} - M_P^2 + \frac{1}{q_2^2}\left(P_1q_2 - \frac{P_1q_1}{q_1^2}q_1q_2\right)^2\right] \\ &\quad + \frac{F_2(x_1, M^2)F_2(x_2, M^2)}{(P_1q_1)(P_2q_2)}\Bigg[P_1P_2 - \frac{(P_1q_1)(P_2q_1)}{q_1^2} - \frac{(P_2q_2)(P_1q_2)}{q_2^2} \\ &\qquad\qquad + \frac{(P_1q_1)(P_2q_2)(q_1q_2)}{q_1^2q_2^2}\Bigg]^2 \\ &\quad + \frac{F_3(x_1, M^2)F_3(x_2, M^2)}{2(P_1q_1)(P_2q_2)}\left[(P_1P_2)(q_1q_2) - (P_1q_2)(P_2q_1)\right]\Bigg\} dx_1dx_2\frac{dPS_3}{\hat s} \end{aligned} \tag{13}$$

where dPS_3 denotes the three-particle phase space of the final-state particles, M_P the proton mass, $P_{1,2}$ the proton momenta and $q_{1,2}$ the momenta of the virtual vector bosons V^*. The functions $F_i(x, M^2)$ $(i = 1, 2, 3)$ are the usual structure functions from deep-inelastic scattering processes at the factorization scale M:

$$
\begin{aligned}
F_1(x, M^2) &= \sum_q (v_q^2 + a_q^2)[q(x, M^2) + \bar{q}(x, M^2)] \\
F_2(x, M^2) &= 2x \sum_q (v_q^2 + a_q^2)[q(x, M^2) + \bar{q}(x, M^2)] \\
F_3(x, M^2) &= 4 \sum_q v_q a_q[-q(x, M^2) + \bar{q}(x, M^2)]
\end{aligned} \tag{14}
$$

where v_q and a_q have been defined previously.

In the past the standard QCD corrections have been calculated within the structure function approach [19]. Since at lowest order, the proton remnants are color singlets, at NLO no color will be exchanged between the first and the second incoming (outgoing) quark line and hence the QCD corrections only consist of the well-known corrections to the structure functions $F_i(x, M^2)$ $(i = 1, 2, 3)$. The final result for the QCD-corrected cross section can be obtained from the replacements

$$
F_i(x, M^2) \to F_i(x, M^2) + \Delta F_i(x, M^2, Q^2) \qquad (i = 1, 2, 3) \tag{15}
$$

with [7, 19]

$$
\begin{aligned}
\Delta F_1(x, M^2, Q^2) &= \frac{\alpha_s(\mu)}{\pi} \sum_q (v_q^2 + a_q^2) \int_x^1 \frac{dy}{y} \left\{ \frac{2}{3}[q(y, M^2) + \bar{q}(y, M^2)] \right. \\
&\quad \left[-\frac{3}{4} P_{qq}(z) \log \frac{M^2 z}{Q^2} + (1 + z^2)\mathcal{D}_1(z) - \frac{3}{2}\mathcal{D}_0(z) \right. \\
&\qquad \left. + 3 - \left(\frac{9}{2} + \frac{\pi^2}{3} \right) \delta(1 - z) \right] \\
&\quad \left. + \frac{1}{4} g(y, M^2) \left[-2P_{qg}(z) \log \frac{M^2 z}{Q^2(1 - z)} + 4z(1 - z) - 1 \right] \right\}
\end{aligned} \tag{16}
$$

$$
\begin{aligned}
\Delta F_2(x, M^2, Q^2) &= 2x \frac{\alpha_s(\mu)}{\pi} \sum_q (v_q^2 + a_q^2) \int_x^1 \frac{dy}{y} \left\{ \frac{2}{3}[q(y, M^2) + \bar{q}(y, M^2)] \right. \\
&\quad \left[-\frac{3}{4} P_{qq}(z) \log \frac{M^2 z}{Q^2} + (1 + z^2)\mathcal{D}_1(z) - \frac{3}{2}\mathcal{D}_0(z) \right. \\
&\qquad \left. + 3 + 2z - \left(\frac{9}{2} + \frac{\pi^2}{3} \right) \delta(1 - z) \right] \\
&\quad \left. + \frac{1}{4} g(y, M^2) \left[-2P_{qg}(z) \log \frac{M^2 z}{Q^2(1 - z)} + 8z(1 - z) - 1 \right] \right\}
\end{aligned} \tag{17}
$$

$$\Delta F_3(x,M^2,Q^2) = \frac{\alpha_s(\mu)}{\pi}\sum_q 4v_q a_q \int_x^1 \frac{dy}{y}\left\{\frac{2}{3}[-q(y,M^2)+\bar{q}(y,M^2)]\right.$$
$$\left[-\frac{3}{4}P_{qq}(z)\log\frac{M^2 z}{Q^2}+(1+z^2)\mathcal{D}_1(z)-\frac{3}{2}\mathcal{D}_0(z)\right.$$
$$\left.\left.+2+z-\left(\frac{9}{2}+\frac{\pi^2}{3}\right)\delta(1-z)\right]\right\}, \tag{18}$$

where $z = x/y$ and the Altarelli–Parisi splitting functions P_{qq}, P_{qg} are as given before. We introduced the notation $\mathcal{D}_i(z) = (\log^i(1-z)/(1-z))_+$ $(i = 0,1)$. The physical scale Q is given by $Q^2 = -q_i^2$ for $x = x_i$ $(i = 1,2)$. These expressions have to be inserted in eq. (13) and the full result expanded up to NLO. The typical renormalization and factorization scales are fixed by the corresponding vector-boson momentum transfer $\mu^2 = M^2 = -q_i^2$ for $x = x_i$ $(i = 1,2)$.

The inclusion of the (two) vertex corrections due to the squark-gluino vertex diagrams and the corresponding self-energy counterterms, assuming that the quarks are massless and the squarks degenerate in mass, can be performed by shifting the functions $F_i(x_j,M^2)$ in eq. (13) by $(i = 1,\ldots,3$ and $j = 1,2)$

$$F_i(x_j,M^2) \to F_i(x_j,M^2)\left[1+\frac{2}{3}\frac{\alpha_s(\mu)}{\pi}\Re e C(q_j^2,m_{\tilde{q}},m_{\tilde{g}})\right] \tag{19}$$

where the function $C(\hat{s},m_{\tilde{q}},m_{\tilde{g}})$ has been given in eq.(10).

3. Numerical Results

We will perform our numerical analysis for the light scalar Higgs boson h in the decoupling limit of large pseudoscalar masses, $M_A \sim 1$ TeV. In this case the light h boson couplings to standard particles approach the SM values. In our analysis we will investigate the Higgs strahlung process $q\bar{q} \to hV$ and the vector boson fusion mechanism $qq \to qqV^*V^* \to qqh$ $[V = W,Z]$.

In Fig. 2, we show the cross sections for these processes at LO and at NLO with only the standard QCD corrections included, as a function of the h boson mass [which can be made varied by varying the parameter $\tan\beta$] for Tevatron and LHC energies. The NLO (LO) cross sections are convoluted with CTEQ4M (CTEQ4L) parton densities [28] and NLO (LO) strong couplings α_s. As can be inferred from the figure, the standard QCD corrections increase the Higgs-strahlung cross sections by about 30% (40%) at the LHC (upgraded Tevatron) and the fusion process by about 10% (5%) at the LHC (upgraded Tevatron).

For the SUSY–QCD corrections, we evaluated the Higgs mass for $\tan\beta = 30$, $M_A = 1$ TeV and vanishing mixing in the stop sector; this yields a value $M_h = 112.6$ GeV for the light scalar Higgs mass. For the sake of simplicity we decompose the K factors

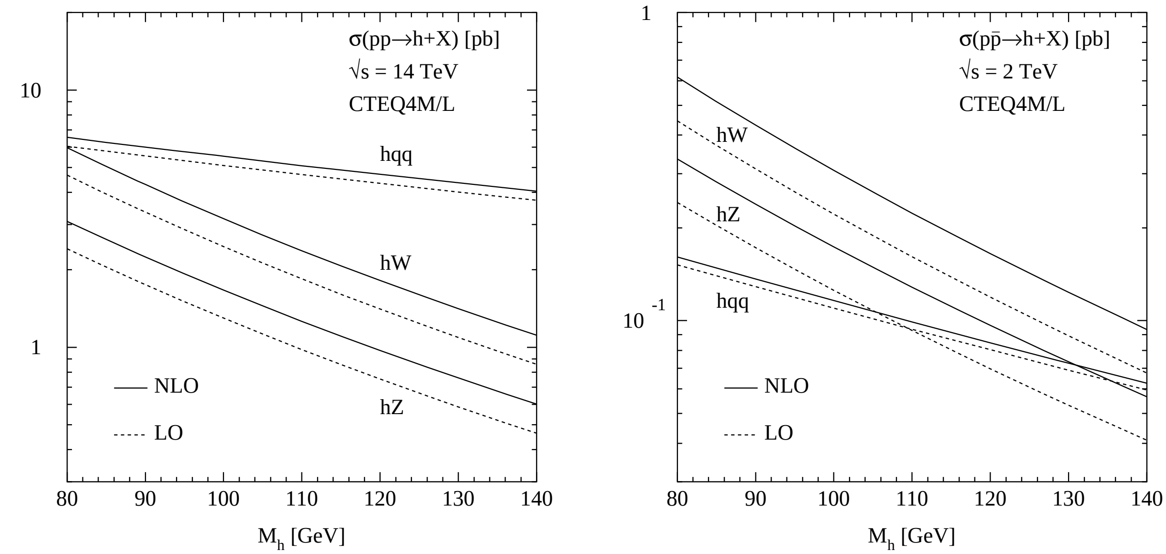

Figure 2: *Total LO and NLO cross sections of Higgs boson production via Higgs-strahlung $q\bar{q} \to h + W/Z$ and vector boson fusion $qq \to qqV^*V^* \to qqh$ [$V = W, Z$] at the LHC (left) and the Tevatron (right) in the decoupling limit.*

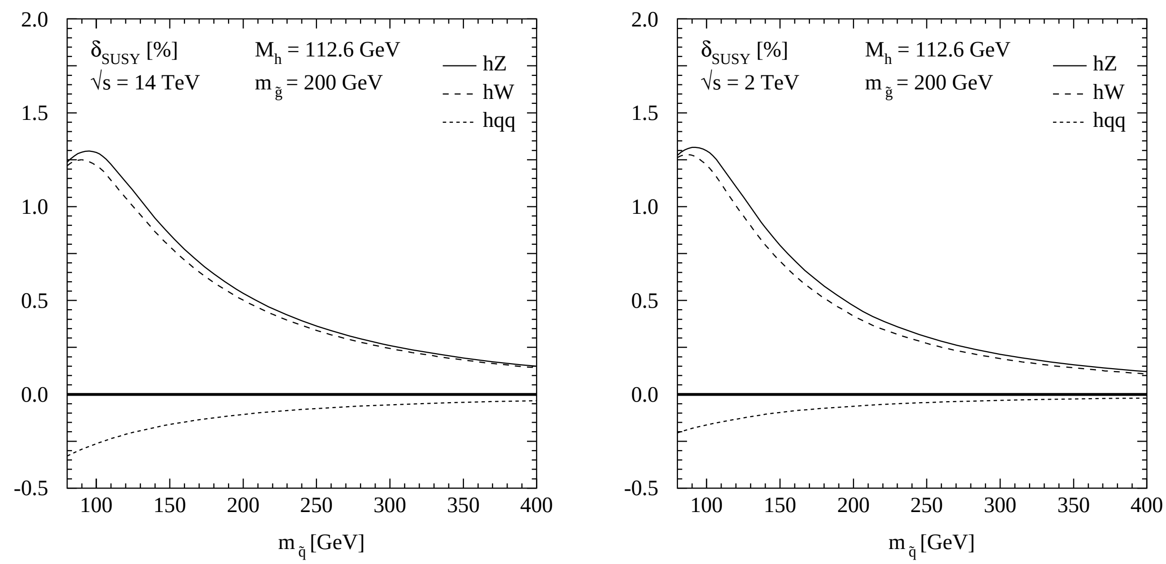

Figure 3: *Relative corrections due to virtual squark and gluino exchange diagrams to Higgs boson production via Higgs-strahlung $q\bar{q} \to h + W/Z$ and vector boson fusion $qq \to qqV^*V^* \to qqh$ [$V = W, Z$] at the LHC (left) and the Tevatron (right).*

$K = \sigma_{NLO}/\sigma_{LO}$ into the usual QCD part K_{QCD} and the additional SUSY correction δ_{SUSY}: $K = K_{QCD} + \delta_{SUSY}$. The additional SUSY-QCD corrections δ_{SUSY} are presented in Fig. 3 as a function of a common squark mass for a fixed gluino mass $m_{\tilde{g}} = 200$ GeV [for the sake of simplicity we kept the stop mass fixed for the determination of the Higgs mass M_h and varied the loop-squark mass independently].

The SUSY-QCD corrections increase the Higgs-strahlung cross sections by less than 1.5%, while they decrease the vector boson fusion cross section by less than 0.5%. The maximal shifts are obtained for small values of the squark masses of about 100 GeV, which are already ruled out by present Tevatron analyses [29]; for more reasonable values of these masses, the corrections are even smaller. Thus, the additional SUSY-QCD corrections, which are of similar size at the LHC and the Tevatron, turn out to be very tiny. For large squark/gluino masses they become even smaller due to the decoupling of these particles, as can be inferred from the upper squark mass range in Fig. 3.

4. Conclusions

In this letter we have determined the SUSY-QCD corrections to Higgs boson production via Higgs-strahlung, Drell–Yan-like Higgs pair production and vector boson fusion at hadron colliders. The additional SUSY corrections originating from the exchange of virtual squarks and gluinos range at the per cent level and are thus rather small. This analysis completes the theoretical calculation of the NLO production cross sections of these processes in the framework of supersymmetric extensions of the Standard Model.

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